PROBLEM OF THE VALUE OF THE LUNAR GRAVITATIONAL FIELD EXPANSION COEFFICIENTS C_{20} AND C_{22}

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ABSTRACT. The discrepancy between the values of the C20 and C22 coefficients (which define the polar and equatorial flattening of the dynamic configuration of the moon) obtained by Gapcynski, Blackshear, and Compton (1969) and previous values obtained by Lorell and Sjogren (1968) and by Michael et al. (1969) is analyzed. It is proposed to calculate these coefficients on the basis of the most probable values of the Cassini-equator inclination and of the g (prime) parameter defining the radial density distribution in the bulk of the moon.

A new analysis of the Moon's gravitational field, based on tracking data for Lunar Orbiters I to V, has been made by Gapcynski, Blackshear, and Compton [1]. In contrast with previous methods, the authors used observational intervals of from 1 to 5 days to compute the gravitational force potential parameters, thus affording improved definition of the higher coefficients. /222*

We note that the values of the coefficients C_{20} and C_{22}, describing the polar and equatorial compression of the Moon's dynamic figure, and evaluated earlier by Lorell and Sjogren [2], and by Michael,

*Numbers in the margin indicate pagination in the original foreign text.

Blackshear, and Gapcynski [3], differ noticeably from those presented in [1]. Table 1 below shows the values of these coefficients, referenced to the principal inertia axes [4].

TABLE 1

Authors	$C_{20} \cdot 10^4$	$C_{22} \cdot 10^4$	f
Lorell et al. [2]	—2.04	0.256	0.58
Michael et al. [3]	—2.07	0.224	0.64
Gapcynski et al. [1]	—2.20	0.333	0.53

We recall that the ratio, f, of the differences in the Moon's moments of inertia is related to C_{20} and C_{22} by the formula:

$$f = \frac{C-B}{C-A} = \frac{C_{20}+2C_{22}}{C_{20}-2C_{22}}. \tag{1}$$

Values of f are given in column 4 of Table 1.

The objective of the present paper is to direct attention to the fact that a comparison of results of Moon satellite trajectory measurements with data of astronomical observations of the Moon's rotation can contribute useful information to the problem of which values of C_{20} and C_{22} are correct.

It is well known that the Moon's dynamic compression depends mainly on the inclination I of the Cassini Equator to the Ecliptic. Again, the quantity β can be expressed in terms of the coefficients C_{20} and C_{22} and the parameter g' describing the radial mass distribution within the Moon, as follows:

$$\beta = -\frac{C_{20}-2C_{22}}{C_{20}+2C_{22}+\frac{2}{3}g'} \tag{2}$$

Since I has been reliably determined from observation ($I = 1°33'$), it can serve as a criterion for choice of C_{20} and C_{22}, if g' is known.

At present, many data indicate that the mass distribution inside the Moon is close to uniform, which corresponds to $g' = 0.60$. We adopt this value in estimating C_{20} and C_{22}. /223

TABLE 2

	Lorell [2]		Michael [3]		Gapcynski [1]	
g'	$\beta \cdot 10^6$	I	$\beta \cdot 10^6$	I	$\beta \cdot 10^6$	I
0.50	766	1°58'.2	756	1°56'.2	856	2°15'.8
0.55	696	1 44.7	687	1 43.1	781	2 01.0
0.60	638	1 33.8	630	1 32.3	716	1 48.7
0.65	589	1 24.7	581	1 23.2	661	1 38.3
0.70	547	1 16.7	540	1 15.3	614	1 29.3

Table 2 shows values of the dynamic compression β, obtained for a number of values of g' and three values of C_{20} and C_{22}. Knowing β we can find the corresponding values of the inclination I. This was done using tables constructed by one of the authors of [5]. The values of I thus computed are shown in columns 3, 5, and 7 of Table 2.

It can be seen that for g' = 0.60 the value of I obtained for the data of Lorell and Sjogren "column 3) and of Michael et al. (column 5) is close to the observed value (1°33'), while for the data of Gapcynski et al. the value obtained is 1°49', which is very far from the observed value.

Hence we conclude that if the hypothesis as to the Moon's uniformity is near the truth, i.e., if g' ≅ 0.60, there is a preference for the values of C_{20} and C_{22} obtained in [2] and [3]. The values of C_{20} C_{22} obtained by Gapcynski et al. [1] require the assumption of g' = 0.67, which corresponds to a noticeable increase in lunar density from the center to the surface, i.e., to a phenomenon which would be hard to explain.

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